January 1993

Physics 30

Grade 12 Diploma Examination

Alberta
EDUCATION

January 1993

Physics 30

Grade 12 Diploma Examination

Description

Time allotted: 2.5 h
Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

Part A
has 42 multiple-choice questions each with a value of one mark.

Part B
has 7 numerical-response questions each with a value of one mark.

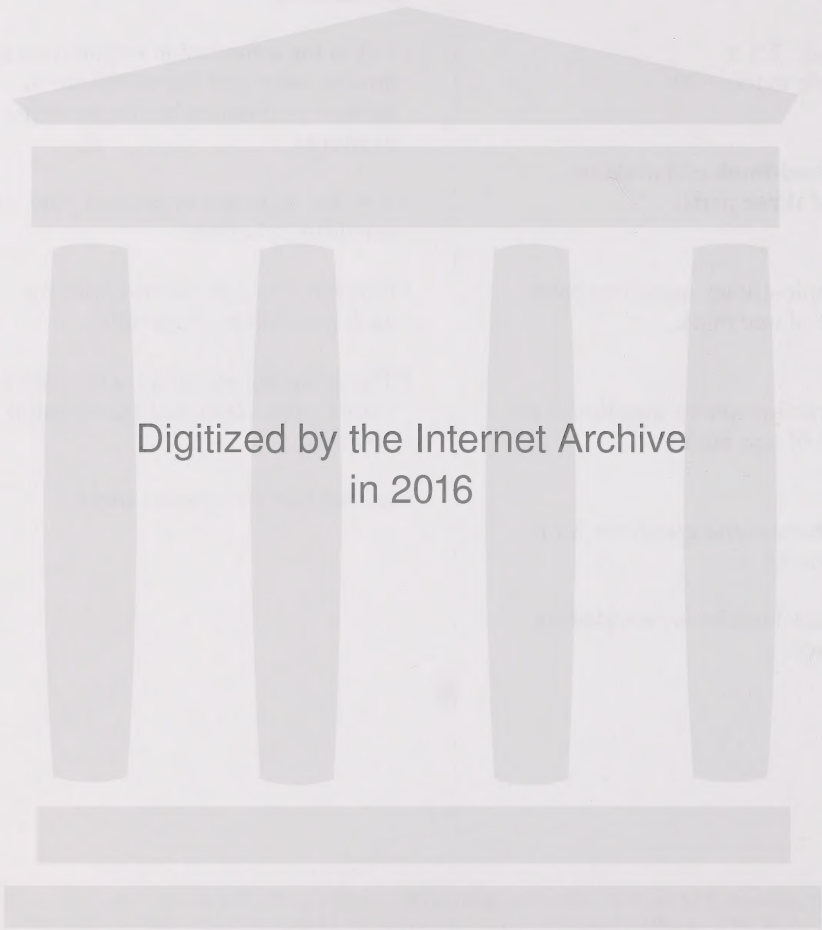
Part C
has 4 written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Carefully read the instructions for each part before proceeding.
- The presiding examiner will collect your answer sheet and examination booklet.
- Do not fold the answer sheet.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*



Part A: Multiple Choice

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully and decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This diploma examination is for the subject of

A. biology
B. physics
C. chemistry
D. mathematics

Answer Sheet

Ⓐ ● Ⓒ Ⓓ

- **Use an HB pencil only.**
- If you wish to change an answer, erase **all** traces of your first answer.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Do not turn the page to start the examination until told to do so by the presiding examiner.

1. A shirt is red when illuminated with white light. When this shirt is illuminated with pure blue light, it will appear to be

   A. purple
   B. black
   C. blue
   D. red

2. A beam of monochromatic light passes through a double slit and produces an interference pattern on a screen. If the slit separation is doubled and the distance to the screen is also doubled, the fringe separation will be

   A. quadrupled
   B. the same
   C. doubled
   D. halved

3. Microwaves with a wavelength of 1.00×10^{-2} m take 6.10×10^{-11} s longer to travel through 3.00×10^{-2} m of glass than to travel the same distance through air. The index of refraction of the glass is

   A. 0.63
   B. 1.41
   C. 1.61
   D. 1.64

4. The polarization of light can be best explained in terms of

   A. particles with different amounts of energy
   B. particles of different sizes
   C. longitudinal waves
   D. transverse waves

5. When monochromatic light passes from air into a glass prism, changes occur in

A. frequency and wavelength only
B. wave velocity and frequency only
C. wave velocity and wavelength only
D. frequency, wavelength, and wave velocity

6. A metal coin placed in the bottom of a pail will appear to rise as the pail is filled with water. This observation can be explained in terms of

A. reflection
B. refraction
C. diffraction
D. polarization

7. The scattering of light is inversely proportional to the fourth power of the wavelength. When compared to red light of wavelength 6.7×10^{-7} m, violet light of wavelength 4.1×10^{-7} m is scattered

A. 7.1 times as much
B. 1.6 times as much
C. 0.61 times as much
D. 0.14 times as much

8. A beam of visible light is unpolarized. To completely block out this beam, a single square of polarizing material should be

A. rotated 90°
B. folded from left to right
C. folded from bottom to top
D. folded from bottom left to top right

9. In a double slit experiment, the screen is 2.0 m from the double slit and the wavelength of the light is 5.0×10^{-7} m. What slit separation would produce a second-order fringe 1.0×10^{-2} m from the central bright spot?

A. 5.0×10^{-7} m

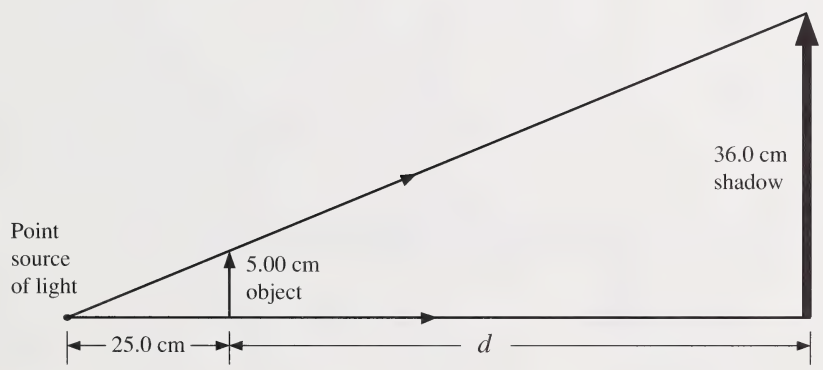
B. 1.0×10^{-4} m

C. 2.0×10^{-4} m

D. 1.0×10^{-2} m

Use the following information to answer question 10.

Shadow Formation by a Point Source



10. An object 5.00 cm high is placed 25.0 cm from a point source of light. A shadow 36.0 cm high appears on a screen. At what distance, d, behind the object is the screen placed?

A. 7.20 cm

B. 32.2 cm

C. 155 cm

D. 180 cm

11. A positively charged rod is brought close to but does not touch an uncharged electroscope. The charges on the electroscope knob and leaves respectively are

A. negative and negative
B. negative and positive
C. positive and negative
D. positive and positive

12. Three equally charged spheres, X, Y, and Z, lie in a straight line with Y between X and Z. The distance between the centres of X and Y is 2.0 cm and the distance between the centres of Y and Z is 1.0 cm. The ratio of the force that Y exerts on Z compared with the force that Y exerts on X is

A. 1:2
B. 2:1
C. 3:1
D. 4:1

13. Which of the following **cannot** be represented by a field?

A. Time
B. Air pressure
C. Temperature
D. Light intensity

14. The statement "current varies directly as the potential difference and inversely as the resistance" is an expression of

A. Coulomb's law
B. Faraday's law
C. Ampère's law
D. Ohm's law

15. The acceleration of an electron in a uniform electric field of magnitude 5.0×10^{-4} N/C is

A. 5.5×10^{26} m/s^2

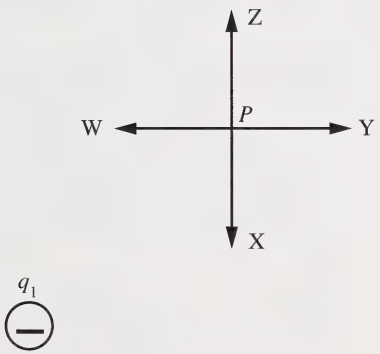
B. 8.0×10^{-23} m/s^2

C. 8.8×10^{7} m/s^2

D. 9.0×10^{6} m/s^2

Use the following information to answer question 16.

Electric Field from Two Point Charges



In the diagram, q_1 and q_2 are charges of equal magnitude but opposite sign. Point P is equidistant from q_1 and q_2.

16. The direction of the net electric field at point P is the same as direction

A. W

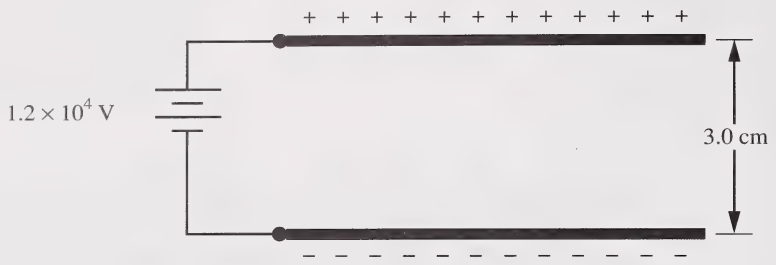
B. X

C. Y

D. Z

Use the following information to answer question 17.

Electric Field between Parallel Plates



Two parallel metal plates are connected to a high-voltage power supply.

17. The electric field between the plates has a magnitude of

A. 3.6×10^2 N/C
B. 4.0×10^3 N/C
C. 3.6×10^4 N/C
D. 4.0×10^5 N/C

---

18. A hydrogen ion ($^1_1H^+$) and a lithium ion ($^7_3Li^{3+}$) are both accelerated through a potential difference of 200 V. The ratio of the kinetic energy that the lithium ion acquires compared with the kinetic energy that the hydrogen ion acquires is

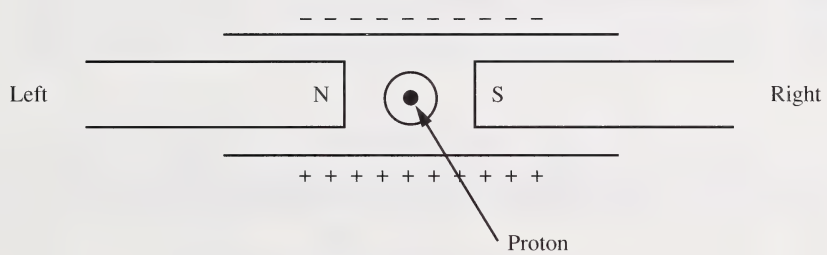
A. 1:1
B. 3:1
C. 6:1
D. 7:1

19. A unit combination equivalent to V/m is

A. N/C
B. N/A
C. J/C
D. J/A

Use the following information to answer question 20.

Proton in Perpendicular Electric and Magnetic Fields



20. A proton emerging in a direction out of the page encounters a magnetic field and an electric field at right angles to each other, as indicated in the diagram. The proton will deflect toward the

A. top of the page
B. bottom of the page
C. left side of the page
D. right side of the page

21. In a magnetic field, a charged particle with a mass of 1.7×10^{-25} kg travels in a circular path of radius 3.5 m at a velocity of 2.0×10^{5} m/s. If the magnitude of the magnetic field is 1.0×10^{-2} T, then the charge on the particle is

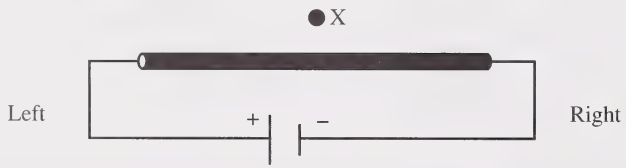
A. 1.9×10^{-15} C
B. 3.4×10^{-18} C
C. 4.9×10^{-24} C
D. 9.8×10^{-19} C

22. Which of the following conditions does **not** produce a magnetic field?

A. An electric field of decreasing magnitude
B. An electric field of increasing magnitude
C. An electric field that is changing in time
D. An electric field that is constant in time

Use the following information to answer question 23.

Magnetic Field of an Electric Current



A current is present in a piece of copper rod.

23. The direction of the magnetic field at point X is

A. out of the page
B. into the page
C. to the right
D. to the left

24. A radar beam travels to a cliff, reflects, and returns to the radar set in 3.0×10^{-4} s. The distance from the radar set to the cliff is

A. 9.0×10^{4} m
B. 4.5×10^{4} m
C. 1.8×10^{5} m
D. 1.0×10^{12} m

25. Which of the following statements about electromagnetic waves in a vacuum is **not** true?

A. Electromagnetic waves are transverse.
B. Electromagnetic waves can be plane polarized.
C. Electromagnetic waves are radiated whenever an electric charge is accelerated.
D. Electromagnetic waves differ from one another in both wavelength and speed.

26. A spacecraft approaching Earth at a speed of 2.5×10^{8} m/s sends a microwave signal when the craft is 1.0×10^{5} km away. The signal will reach Earth in

A. 2.0 s
B. 0.40 s
C. 0.33 s
D. 0.18 s

27. Compared with visible light waves, ultraviolet waves have a

A. higher speed
B. greater period
C. lower frequency
D. shorter wavelength

28. A potential difference of 1.0×10^2 V is applied across two parallel horizontal plates that are separated by a distance of 0.10 m. An oil drop of mass 3.9×10^{-16} kg is held stationary by the electric field. The charge on the oil drop is

A. 1.6×10^{-19} C
B. 3.8×10^{-18} C
C. 1.6×10^{-17} C
D. 3.8×10^{-16} C

29. Dalton proposed that the atomic masses of all elements be expressed relative to the atomic mass of hydrogen because hydrogen

A. atoms appeared to have a smaller mass than atoms of other elements
B. appeared to be the most common of the known elements
C. atoms combined with oxygen atoms in one-to-one ratio
D. was present in all chemical compounds

30. Photons have the greatest energy if they are

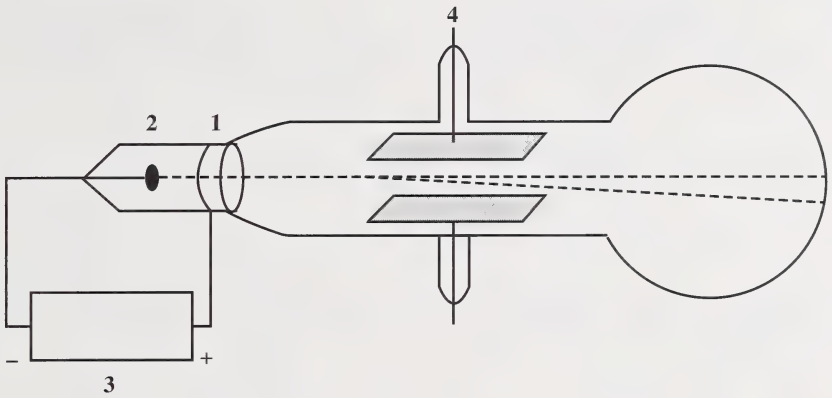
A. microwave
B. ultraviolet
C. infra-red
D. X-ray

31. A television picture tube operates with a potential difference of 3.0×10^4 V. If X-rays are emitted from this picture tube, the minimum wavelength of the X-rays would be

A. 7.2×10^{18} m
B. 4.1×10^{-11} m
C. 2.4×10^{10} m
D. 1.0×10^{-4} m

Use the following information to answer question 32.

Cathode Ray Tube



32. Which numbered component is the cathode?

A. 1
B. 2
C. 3
D. 4

---

33. In an electrolysis apparatus, a current of 2.0 A plates out metallic copper from Cu^{2+} ions. How much copper will be plated out in 5.0 min?

A. 3.3×10^{-4} g
B. 9.0×10^{-2} g
C. 0.20 g
D. 0.40 g

Use the following information to answer question 34.

A gas sample is bombarded with electrons. The kinetic energies of the incident and scattered electrons are recorded in the following table:

Kinetic Energy of Incident Electrons (10^{-2} eV)	Kinetic Energy of Scattered Electrons (10^{-2} eV)
7.00	7.00
8.00	8.00
12.00	3.50
13.50	5.00

34. If this gas sample is heated, it could emit electromagnetic radiation with a wavelength of

A. 2.34×10^{-24} m

B. 1.55×10^{-5} m

C. 1.46×10^{-5} m

D. 1.36×10^{-20} m

---

35. When the frequency of electromagnetic radiation is doubled, each photon's momentum

A. doubles and its energy doubles

B. doubles and its energy does not change

C. remains the same but its energy doubles

D. remains the same but its energy quadruples

36 . If an X-ray photon with a frequency of 3.60×10^{17} Hz loses 0.10% of its energy when it collides with an electron at rest, the electron has recoiled with a speed of

A. 8.7×10^{-1} m/s
B. 5.2×10^{5} m/s
C. 7.2×10^{5} m/s
D. 5.2×10^{11} m/s

37. A photon of wavelength 5.0×10^{-7} m has the same momentum as an electron. The speed of this electron is

A. 6.9×10^{-4} m/s
B. 3.8×10^{-1} m/s
C. 2.7×10^{2} m/s
D. 1.5×10^{3} m/s

38. The kinetic energy of an electron with a relativistic mass of 9.87×10^{-31} kg is

A. 4.4×10^{-14} J
B. 6.8×10^{-15} J
C. 8.2×10^{-14} J
D. 8.9×10^{-14} J

39. The position of atomic particles of diameter D can be determined most precisely by using radiation of wavelength

A. $0.5D$
B. $2.0D$
C. $4.0D$
D. $10D$

40. Who said "It is impossible to simultaneously determine both the position and speed of an electron with unlimited accuracy"?

A. Einstein
B. Compton
C. Heisenberg
D. Schrödinger

41. The momentum of a photon varies

A. inversely as its wavelength
B. inversely as its frequency
C. directly as its wavelength
D. directly as its speed

42. Schrödinger's mathematical description of the electron is based on the assumption that the electron behaves like a

A. relativistic mass
B. Bohr atom
C. particle
D. wave

You have now completed Part A. Proceed directly to Part B.

Part B: Numerical Response

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**
- Use an HB pencil only.
- If you wish to change an answer, erase **all** traces of your first answer.

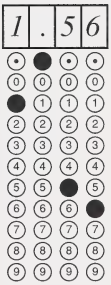
Sample Questions and Solutions

If the angle of incidence in air is 47.6° and the angle of refraction is 28.3°, the index of refraction is _____.
(Round and record your answer to three digits.)

$$n = \frac{\sin \theta_1}{\sin \theta_2}$$

$$n = \frac{\sin 47.6°}{\sin 28.3°} = 1.5576328$$

Record 1.56 on the answer sheet →



A microwave of wavelength 16 cm has a frequency of $b \times 10^9$ Hz. The value of b is _____.
(Round and record your answer to two digits.)

$$f = c/\lambda$$

$$= (3.00 \times 10^8 \text{ m/s})/(0.16 \text{ m})$$

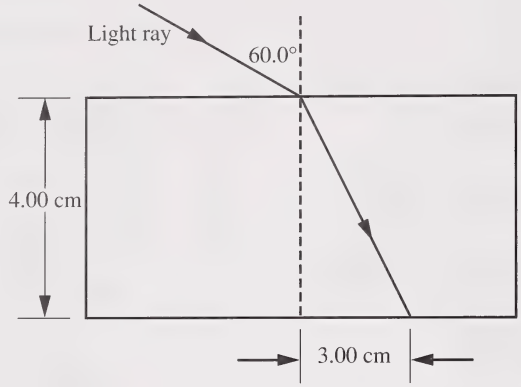
$$f = 1.875 \times 10^9 \text{ Hz}$$

Record 1.9 on the answer sheet →

Start Part B immediately.

Use the following information to answer question 1.

Refraction of Light in Glass



A light ray refracts when it enters a glass block from air.

1. The index of refraction of the glass is _____.
(Round and record your answer to three digits.)

YOUR ANSWER ON THE ANSWER SHEET

2. A charged particle experiences a force of 4.62 N when it passes through a magnetic field. If the same particle were sent at exactly half its previous speed, through a magnetic field exactly four times as strong, the particle would experience a force of _____ N.
(Round and record your answer to three digits.)

Use the following information to answer question 3.

The frequency and wavelength of an incident wave are determined experimentally to be 2.45×10^9 Hz and 0.112 m respectively. The speed of the electromagnetic wave may be calculated from these data.

3. The percentage error associated with the speed of light calculated from these data is _____ %.
(Round and record your answer to two digits.)

4. Electromagnetic radiation of frequency 4.24×10^6 Hz enters a medium that has a refractive index of 1.21. In this medium, the radiation has a wavelength of _____ m.
(Round and record your answer to three digits.)

5. One of the energy levels of the hydrogen atom is -1.36×10^{-19} J. The radius of the Bohr orbit that corresponds to this energy state is $\boldsymbol{b} \times 10^{-10}$ m. The value of $\boldsymbol{b}$ is _____.
(Round and record your answer to three digits.)

6. When an X-ray passes through a crystal, it forms a second-order diffraction image on a screen at an angle of deviation of 6.0°. The crystal acts as a diffraction grating with a line spacing of 4.0×10^{-10} m. The distance to the screen is 1.8 m. The wavelength of the X-ray, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ m.
The value of $\boldsymbol{b}$ is _____.
(Round and record your answer to two digits.)

7. A photon has an energy of 1.63×10^{-18} J. The momentum of this photon, expressed in scientific notation, is $b \times 10^{-w}$ kg•m/s. The value of the exponent $\boldsymbol{w}$ is _____.

You have now completed Part B. Proceed to Part C.

Part C: Written Response

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

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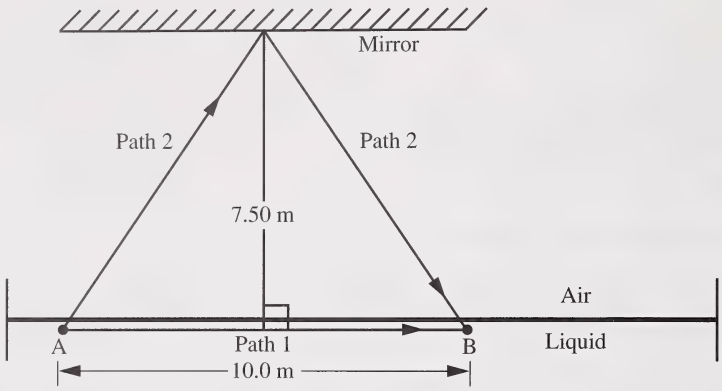
Start Part C immediately.

For Department Use Only

(5 marks)

Use the following information to answer question 1.

Refractive Index from Time Measurements



Two pulses of light are emitted simultaneously at A and travel from A to B along two paths. On path 1, the direct ray travels in the liquid. On path 2, essentially all of which is in air, the ray is reflected from a mirror. The distance between the mirror and the surface of the liquid is adjusted until both rays travel from A to B in the same time interval. The diagram represents the final position of the mirror.

1. a. Determine the time taken by the reflected ray to travel from A to B.

For Department Use Only

b. Determine the refractive index of the liquid.
(**Note:** If you were unable to calculate a value in part a, use the hypothetical value $t = 6.50 \times 10^{-8}$ s.)

For Department Use Only

(7 marks)

2. A student varied the current in a fixed resistor and measured the power dissipated in the resistor for different currents. The experimental data are recorded in the following table:

Current I (A)	Power P (W)
0.10	0.56
0.20	2.3
0.30	4.9
0.40	8.8
0.50	13.0

a. Draw a graph of power as a function of current, with the manipulated variable on the horizontal axis.

For Department Use Only

b. Re-plot the data in a manner that produces a straight-line graph from which the resistance can be found. Clearly label the variables plotted.

c. Use a slope or another averaging procedure to find the **best** estimate for the resistance of the resistor.

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(5 marks)

Use the following information to answer question 3.

When light of wavelength 4.26×10^{-7} m is incident on a metal surface, the maximum kinetic energy of an emitted photoelectron is 2.99×10^{-19} J.

3. **a.** Determine the work function W of the metal surface.

For Department Use Only

b. Light of wavelength 2.54×10^{-7} m is incident on the same metal. Determine the maximum speed of the emitted photoelectrons **and** the stopping voltage.

Be sure to turn the page and answer question 4.

For Department Use Only

(4 marks)

4. Low-frequency radio waves can travel relatively large distances because they are reflected by the ionosphere. The ionosphere is 80 km above the Earth's surface during the day but rises to a height of 110 km at night. With the aid of a suitable diagram, explain why this change in height allows low-frequency radio waves to be received at a greater distance from the source at night.

You have now completed the examination.
If you have time, you may wish to check your answers.

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No marks will be given for work done on this page.

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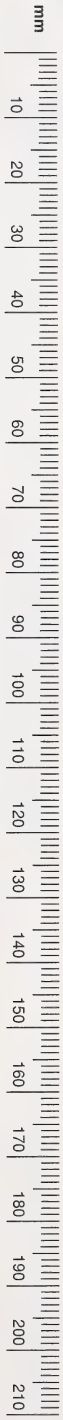

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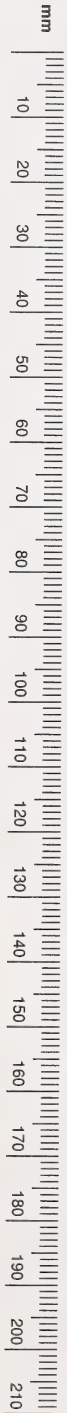

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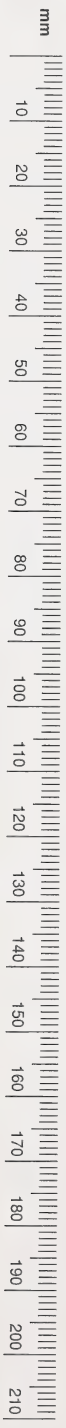

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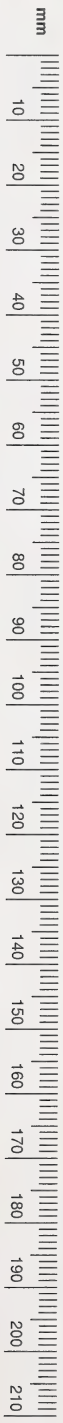

Physics 30
January 1993

Name

Apply Label With Student's Name

Physics 30

(Last Name) (First Name) Y M D

Name: **Date of Birth:** **Sex:**

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M4 **M3** **M2** **M1**

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Physics 30

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PHYSICS 30

MULTIPLE-CHOICE KEY

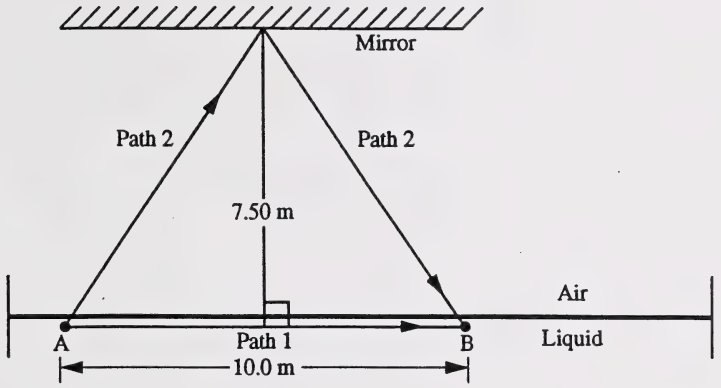
1.	B	22.	D
2.	B	23.	A
3.	C	24.	B
4.	D	25.	D
5.	C	26.	C
6.	B	27.	D
7.	A	28.	B
8.	D	29.	A
9.	C	30.	D
10.	C	31.	B
11.	B	32.	B
12.	D	33.	C
13.	A	34.	C
14.	D	35.	A
15.	C	36.	C
16.	A	37.	D
17.	D	38.	B
18.	B	39.	A
19.	A	40.	C
20.	A	41.	A
21.	D	42.	D

NUMERICAL-RESPONSE KEY

1. 1.44
2. 9.24
3. 8.5
4. 58.5
5. 8.46
6. 2.1
7. 27

Use the following information to answer question 1.

Refractive Index from Time Measurements



Two pulses of light are emitted simultaneously at A and travel from A to B by way of two paths. In path 1, the direct ray travels in the liquid. In path 2, essentially all of which is in air, the ray is reflected from a mirror. The distance between the mirror and the surface of the liquid is adjusted until both rays travel from A to B in the same time interval. The diagram represents the final position of the mirror.

(2 marks)

1. a. Determine the time taken by the reflected ray to travel from A to B.

path distance in air $= 2((5.0\text{ m})^2 + (7.50\text{ m})^2)^{1/2}$

$= 18.0\text{ m}$

$t = d/c$

$= (18.0\text{ m})/(3.00 \times 10^8\text{ m/s})$

$t = 6.01 \times 10^{-8}\text{ s}$

Time for reflected ray $= 6.01 \times 10^{-8}\text{ s}$

3 marks)

b. Determine the refractive index of the liquid.

(**Note:** If you were unable to calculate a value in part a. use the hypothetical value $t = 6.50 \times 10^{-8}$ s.)

$v_{liquid} = d/t$

$= (10.0 \text{ m})/(6.01 \times 10^{-8} \text{ s})$

$v_{liquid} = 1.66 \times 10^{8}$ m/s

$n_2/n_1 = v_1/v_2$

$n_2 = n_1 v_1/v_2$

$= (1.00)(3.00 \times 10^{8} \text{ m/s})/(1.66 \times 10^{8} \text{ m/s})$

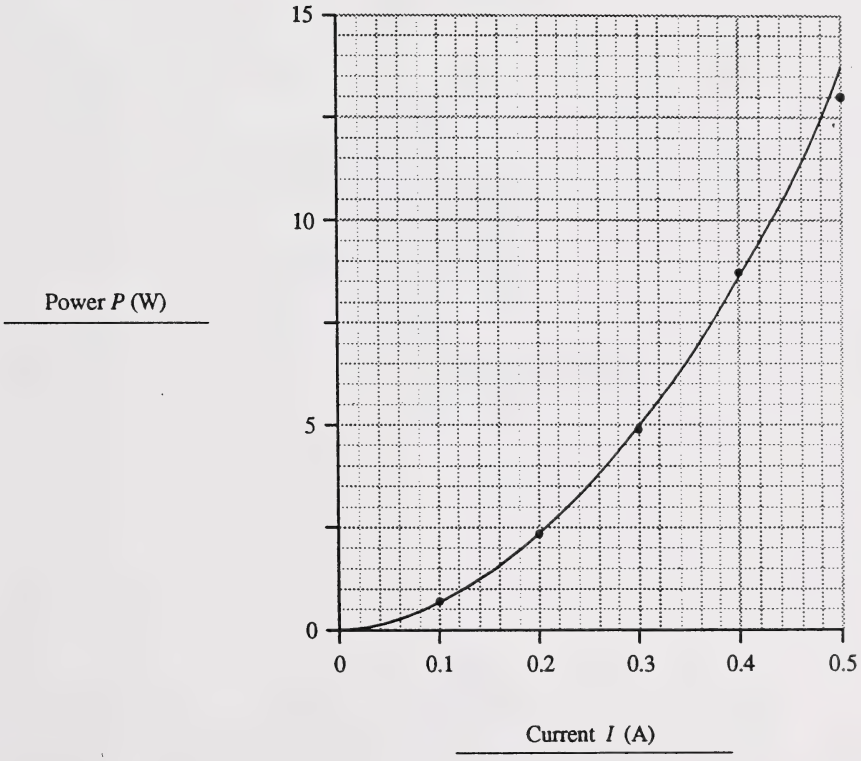
$n_2 = 1.81$

Refractive index of liquid = 1.81

(7 marks) **2.** A student varied the current in a fixed resistor and measured the power dissipated in the resistor for different currents. The experimental data are recorded in the following table:

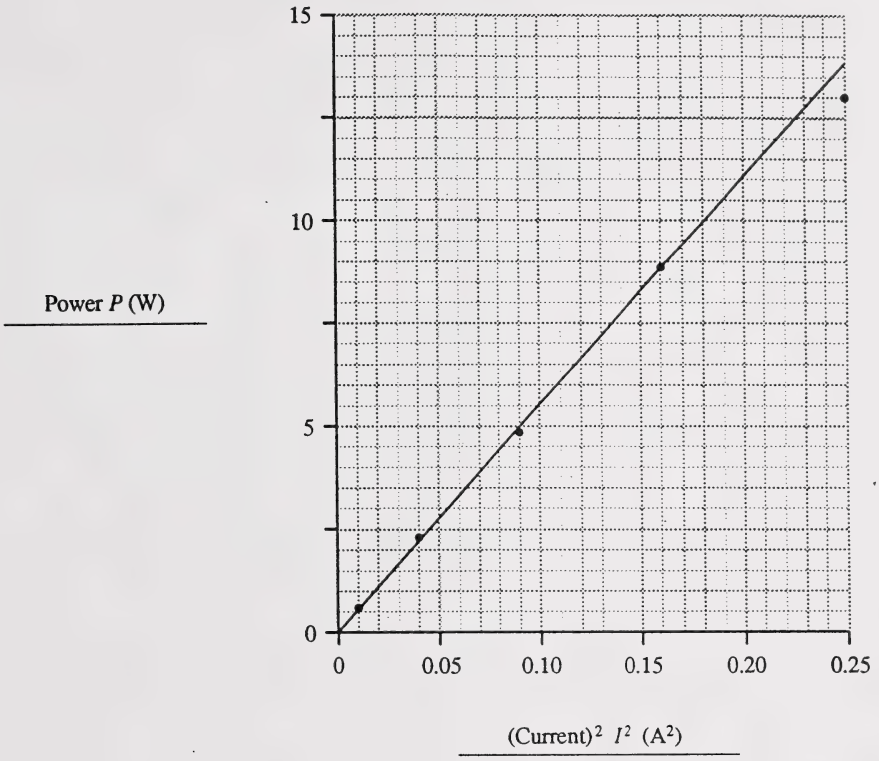
Current I (A)	Power P (W)
0.10	0.56
0.20	2.3
0.30	4.9
0.40	8.8
0.50	13.0

(2 marks) **a.** Draw a graph of power as a function of current, with the manipulated variable on the horizontal axis.



(3 marks)

b. Re-plot the data in a manner that produces a straight-line graph from which the resistance can be found. Label clearly the variables plotted.



(2 marks)

c. Use a slope or another averaging procedure to find the **best** estimate for the resistance of the resistor.

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{P_f - P_i}{I_f^{\,2} - I_i^{\,2}}$$

$$= \frac{(13.8 - 0)\ \text{W}}{(0.25 - 0)\ \text{A}^2}$$

$$\text{slope} = 55.2\ \text{W/A}^2 = 55\ \text{W/A}^2 = 55\ \Omega$$

OR

$$R = P/I^2$$

$$R_1 = 0.56/(0.10)^2 = 56.0\ \Omega$$

$$R_2 = 2.3/(0.20)^2 = 57.5\ \Omega$$

$$R_3 = 4.9/(0.30)^2 = 54.4\ \Omega$$

$$R_4 = 8.8/(0.40)^2 = 55.0\ \Omega$$

$$R_5 = 13.0/(0.50)^2 = 52.0\ \Omega$$

$$R_{\text{total}} = 274.9\ \Omega$$

$$R_{\text{ave}} = \frac{274.9\ \Omega}{5} = 55\ \Omega$$

Use the following information to answer question 3.

When light of wavelength 4.26×10^{-7} m is incident on a metal surface, the maximum kinetic energy of an emitted photoelectron is 2.99×10^{-19} J.

(5 marks)

3. a. Determine the work function W of the metal surface.

$$W = hf - E_k$$

$$= hc/\lambda - E_k$$

$$= \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^{8}\ \text{m/s})}{4.26 \times 10^{-7}\ \text{m}} - 2.99 \times 10^{-19}\ \text{J}$$

$$W = 1.68 \times 10^{-19}\ \text{J}$$

Work function = 1.68×10^{-19} J

b. Light of wavelength 2.54×10^{-7} m is incident on the same metal. Determine the maximum speed of the emitted photoelectrons **and** the stopping voltage.

$E_k = hf - W$

$= hc/\lambda - E_k$

$$= \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^{8}\ \text{m/s})}{2.54 \times 10^{-7}\ \text{m}} - 1.68 \times 10^{-19}\ \text{J}$$

$E_k = 6.15 \times 10^{-19}$ J

$E_k = qV$

$V = E_k/q$

$= (6.15 \times 10^{-19}\ \text{J})/(1.60 \times 10^{-19}\ \text{C})$

$V = 3.84$ V

Stopping voltage = 3.84 V

$E_k = \frac{1}{2}mv^2$

$v = (2E_k/m)^{1/2}$

$= (2(6.15 \times 10^{-19}\ \text{J})/(9.11 \times 10^{-31}\ \text{kg}))^{1/2}$

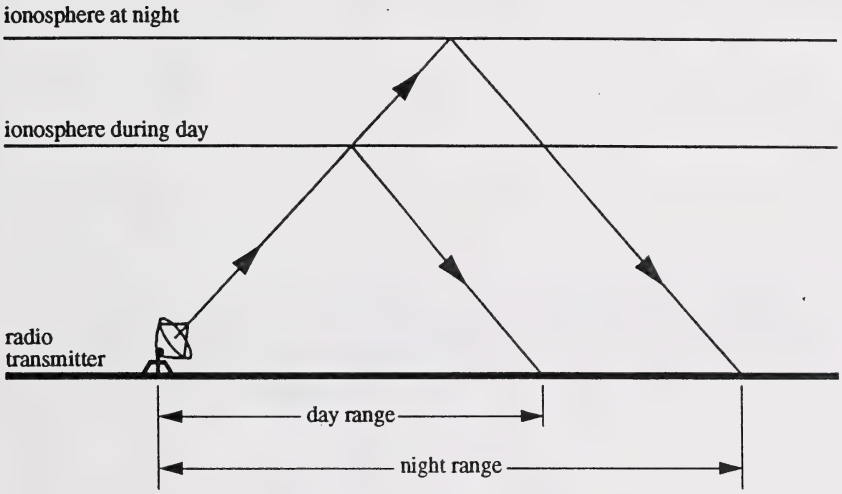
$v = 1.16 \times 10^{6}$ m/s

Maximum speed of photoelectrons = 1.16×10^{6} m/s

(4 marks)

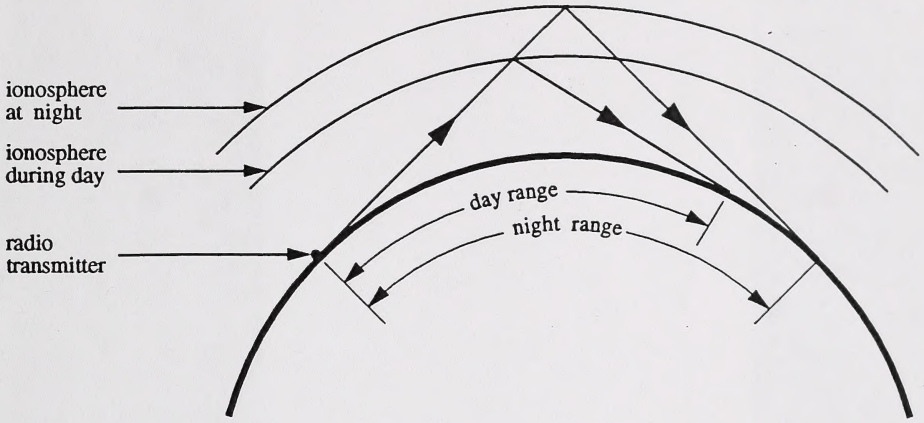
4. Low-frequency radio waves can travel relatively large distances because they are reflected by the ionosphere. The ionosphere is 80 km above the Earth's surface during the day but rises to a height of 110 km at night.
With the aid of a suitable diagram, explain why this change in height allows low-frequency radio waves to be received at a greater distance from the source during night time.

Method one: using a flat Earth



Radio waves reflecting from the ionosphere obey the Law of Reflection. For any given fixed angle of transmission, the waves travel farther at night before being reflected by the ionosphere than in the day. This results in the range being greater at night than in the day.

Method two: using a curved Earth



Maximum range of radio transmission is achieved by aiming the radio beam tangentially to the Earth's surface (see diagram). Radio waves incident on the ionosphere obey the Law of Reflection. As the ionosphere rises at night the waves travel farther before being reflected, resulting in a greater range at night than in the daytime.